CERTIFICATE

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[Title of the Invention] DISPLAY DEVICE AND ELECTRONIC APPARATUS

[Claims]

[Claim 1] A display device comprising at least one substrate provided with a display unit and display-unit-driving wiring lines, and a radio communication device having a communication integrated-circuit unit and an antenna, wherein at least a part of the antenna is formed on the substrate and is formed of a conductor formed in the same layer as a conductor that constitutes the display unit or conductors that constitute the display-unit-driving wiring lines.

[Claim 2] A display device comprising at least one substrate provided with a display unit and display-unit-driving wiring lines, and a radio communication device having a communication integrated-circuit unit and an antenna,

wherein at least a part of the antenna is formed on the substrate and is formed of a conductor made of the same material as a conductor that constitutes the display unit or conductors that constitute the display-unit-driving wiring lines.

[Claim 3] A display device comprising at least one substrate provided with a display unit and display-unit-

driving wiring lines, and a radio communication device having a communication integrated-circuit unit and an antenna, wherein at least a part of the antenna is formed on the substrate and is formed of a conductor formed by the same process as a conductor that constitutes the display unit or conductors that constitute the display-unit-driving wiring lines.

[Claim 4] The display device according to any one of Claims 1 to 3, wherein the radio communication device has a function of storing information concerning the corresponding display device.

[Claim 5] The display device according to any one of Claims 1 to 3, wherein the radio communication device has at least one of a function of writing information in a radio communication device other than the corresponding display device and a function of reading information from the radio communication device other than the corresponding display device.

[Claim 6] The display device according to any one of Claims 1 to 5, wherein the communication integrated-circuit unit is mounted on the substrate.

[Claim 7] The display device according to Claim 6, wherein the communication integrated-circuit unit and the antenna are electrically connected to each other through the conductor formed in the same layer as the conductor that

constitutes the display unit or the conductors that constitute the display-unit-driving wiring lines.

[Claim 8] The display device according to any one of Claims 1 to 5, wherein an external substrate for driving the display unit is electrically connected to the substrate and a conductor provided on the external substrate is electrically connected to the antenna formed on the substrate so that the conductor on the external substrate and the antenna on the substrate constitute an entire antenna, and wherein the communication integrated-circuit unit is mounted on the external substrate.

[Claim 9] The display device according to Claim 8, wherein the external substrate is constituted of a plurality of external substrates, and the communication integrated-circuit unit is mounted on one of the plurality of external substrates.

[Claim 10] The display device according to any one of Claims 1 to 5, wherein the communication integrated-circuit unit is constituted of a plurality of semiconductor elements formed on the substrate.

[Claim 11] The display device according to Claim 10, wherein the plurality of semiconductor elements that constitute the communication integrated circuit has the same structure as another semiconductor element formed on the substrate.

[Claim 12] The display device according to any one of Claims 1 to 11, wherein at least a part of the antenna is formed on the substrate in a region excluding the display unit.

[Claim 13] The display device according to Claim 12, wherein at least a part of the antenna is formed along one peripheral edge of the substrate.

[Claim 14] The display device according to any one of Claims 1 to 13, wherein the conductor formed above the antenna on the substrate to constitute the corresponding display device does not overlap the antenna in plan view.

[Claim 15] A display device comprising at least one substrate provided with a display unit and display-unit-driving wiring lines, and a radio communication device having a communication integrated-circuit unit and an antenna,

wherein at least a part of the radio communication device is directly formed on the substrate.

[Claim 16] An electronic apparatus comprising the display device according to any one of Claims 1 to 15.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a display device including a radio communication device and an electronic

apparatus.

[0002]

[Description of the Related Art]

A production method referred to as obtaining a plurality of liquid crystal cell patterns, in which the plurality of liquid crystal cell patterns is simultaneously formed on one mother board, two mother boards are attached to each other, and the mother boards are divided into individual cells, is adopted for a display device such as a liquid crystal display (See the patent document 1 for reference). The production method is extremely effective. However, according to the production method, after dividing the mother boards into individual cells, many additional processes such as connection of a driving flexible printed circuit (abbreviated to as FPC, hereinafter) must be performed before a complete liquid crystal module product is provided. In particular, after dividing the mother boards into individual cells, it is difficult to let each product have product identification information such as a lot number, a mother board number, and a product number and product record information such as a manufacturing factory and the date of manufacture. Therefore, for example, production line workers manage products and processes by recording product information. Such complicated product and process management procedures affect distribution processes

as well as production processes.

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 2002-268042

[0004]

[Problems to be Solved by the Invention]

As a method of effectively managing products and inventory, barcodes are used as information recording media in a conventional technology. According to the method, when the barcodes are attached to products, various information items can be simply read by a reader to thus manage information using a computer. Further, radio communication devices (information recording media) using a RFID (radio frequency identification) technology, which are referred to as IC tags and RFID tags, have recently attracted attention as an alternative to barcodes. The IC tags can perform communications between readers and writers without contact and can manage products and inventory by exchanging information items in the memories mounted in the IC tags. Also, the IC tags are superior to barcodes in that information items can be added or changed at any time.

[0005]

For example, when an IC tag is desired to be used for the product and process management of a liquid crystal display device, it is necessary to attach an IC tag that

includes an IC chip and an antenna outside the display area of the liquid crystal display device. Since liquid crystal display devices are being miniaturized with each succeeding design, in the liquid crystal display device, the area of the peripheral edge (a frame region or an abandoned region) outside the display area is small. Also, liquid crystal display devices that can be curved are available and glass substrates that constitute liquid crystal display devices become thinner. The typical size of a liquid crystal display device, the width of a peripheral edge is 2 mm or less and the thickness of a glass substrate is 0.4 mm or less. On the other hand, according to an example of the size of an IC tag, the typical size of an IC chip is an IC chip of 1 mm × 1 mm and the length of an antenna is several cm. In such an environment, there may be no space for attaching an IC tag to a liquid crystal display device or, even if there is a space for attaching an IC tag to a liquid crystal display device, it requires a great amount of effort and takes a long time to attach a slim IC tag to the space. Therefore, IC tags are not currently used for managing products and processes in liquid crystal display devices. This is a common problem in other display devices as well as liquid crystal display devices.

[0006]

In order to solve the above problems, it is an object

of the present invention to provide display devices and electronic apparatuses including radio communication devices such as IC tags, which do not require special spaces for attaching the same and which are capable of reducing the amount of effort and time for attaching the same.

[0007]

[Means for Solving the Problems]

In order to achieve the above object, it is characterized in that a display device according to the present invention comprises at least one substrate provided with a display unit and display-unit-driving wiring lines, and a radio communication device having a communication integrated-circuit unit and an antenna, in which at least a part of the antenna is formed on the substrate and is formed of a conductor formed in the same layer as a conductor that constitutes the display unit or conductors that constitute the display-unit-driving wiring lines.

[0008]

Another display device according to the present invention is characterized in that at least a part of the antenna is formed on the substrate and is formed of a conductor made of the same material as a conductor that constitutes the display unit or conductors that constitute the display-unit-driving wiring lines.

Another display device according to the present

invention is characterized in that at least a part of the antenna is formed on the substrate and is formed of a conductor formed by the same process as a conductor that constitutes the display unit or conductors that constitute the display-unit-driving wiring lines.

[0009]

The radio communication device such as an IC tag includes a communication integrated circuit and an antenna. The communication integrated circuit has a complicated circuit structure. However, the antenna has a simple structure in which the same is constituted of one line having predetermined width and length. Therefore, the present inventor invented a structure in which the antenna is directly formed on a substrate that constitutes the display device. Also, the paid attention to the fact that a conductor that constitutes various electrodes and switching elements in the display unit or a conductor that constitutes various wiring lines for driving the display unit exists on the substrate of the display device. He also decided to form at least a part of the antenna on the same layer, of the same material, and by the same process as those of the conductor without using a common substrate manufacturing process. According to this structure, since it is possible to form at least a part of the antenna in an arbitrary position where patterns such as the display unit do not

exist, it is not necessary to provide a special space for attaching the antenna. Also, since it is possible to form at least a part of the antenna during a common manufacturing process, it is possible to reduce the amount of effort and time for attaching the antenna.

[0010]

The radio communication device may have a function of storing information concerning the corresponding display device. Further, the radio communication device may have at least one of a function of writing information in a radio communication device other than the corresponding display device and a function of reading information from the radio communication device other than the corresponding display device.

That is, 'the radio communication device' according to the present invention may function as an information storage medium for storing information concerning a corresponding display device, for example, product identification information such as a lot number, a mother board number, and a product number and product record information such as a manufacturing factory and the date of manufacture. The radio communication device according to the present invention may function as a reader/writer for writing the above information to another information storage medium constituted of the radio communication device and reading

the information stored in the information storage medium. At any rate, the structure of the antenna is common. The radio communication device may have one of the two functions according to the structure of the communication integrated circuit.

[0011]

The present invention is characterized in that at least a part of the antenna is formed on the substrate. However, a few forms of the communication integrated circuit exist. For example, there exist (1) a form in which the communication integrated circuit is mounted on the substrate, (2) a form in which the communication integrated circuit is mounted on an external substrate when the external substrate for driving the display unit such as an FPC on which a driving IC is mounted is connected to the substrate, and (3) a form in which the communication integrated circuit is directly formed on the substrate.

[0012]

The structure of form (1) is that a separate communication integrated-circuit unit such as an IC chip is mounted on the substrate. According to such a structure, it is possible to easily mount the radio communication device on the substrate by mounting the separate communication integrated circuit on the substrate. Since the entire radio communication device is arranged on the substrate, when the

communication integrated circuit is mounted on the substrate after the substrate is completed, it is possible to manage products and processes by using the radio communication device from a step before the external substrate for driving the display unit is connected to the substrate.

[0013]

In the structure of form (1), it is necessary to electrically connect the communication integrated circuit to the antenna. In order to the communication integrated-circuit unit and the antenna, it is possible to electrically connect to each other through the conductor formed in the same layer as the conductor that constitutes the display unit or the conductors that constitute the display-unit-driving wiring lines. That is, like the antenna, the conductor for electrically connecting the communication integrated circuit to the antenna is preferably formed of the conductor on the same layer as the conductor that constitutes the display unit or the display-unit-driving wiring lines.

According to this structure, since it is possible to simultaneously form the conductor for electrically connecting the communication integrated circuit to the antenna and the other conductors on the substrate, it is possible to limit the number of processes and to prevent manufacturing processes from being complicated. Therefore,

it is possible to reasonably connect the communication integrated circuit to the antenna.

[0014]

In the structure of form (2), the external substrate for driving the display unit is electrically connected to the substrate and the communication integrated circuit is mounted on the external substrate. In this case, an external substrate for driving the display unit is electrically connected to the substrate and a conductor provided on the external substrate is electrically connected to the antenna formed on the substrate so that the conductor on the external substrate and the antenna on the substrate constitute an entire antenna.

According to this structure, for example, even when the substrate of the display device is small and the antenna formed on the substrate is not long enough, it is possible to compensate the inadequate of the length of the antenna with the additional length of the conductor on the external substrate and to thus obtain an antenna having a desired performance. Therefore, it is possible to increase the degree of freedom in designing the antenna. Since many wiring lines are originally provided in the external substrate for driving the display unit, it is not necessary to additionally provide an antenna conductor on the external substrate.

[0015]

In the structure of form (2), the external substrate is constituted of a plurality of external substrates, and the communication integrated-circuit unit is mounted on one of the plurality of external substrates.

The driving substrate (a first external substrate) such as the FPC may be connected to the substrate of the display device. The driving substrate may be connected to another circuit substrate (a second external substrate) such as a printed wiring line board. 'The plurality of external substrates' according to the present invention includes such a substrate. According to the above structure, the communication integrated circuit may be mounted on either the first external substrate or the second external substrate. In the above case, when the communication integrated circuit is mounted on the second external substrate, an entire antenna may be constituted of the antenna on the substrate, the conductor on the first external substrate, and the conductor on the second external substrate.

[0016]

In the structure of form (3), the communication integrated-circuit unit is constituted of a plurality of semiconductor elements formed on the substrate.

According to this structure, it is not necessary to

provide an additional communication integrated circuit formed of an IC chip and to mount the communication integrated circuit on the substrate.

[0017]

In the structure of form (3), the plurality of semiconductor elements that constitute the communication integrated circuit may have the same structure as another semiconductor element formed on the substrate.

A pixel switching semiconductor element of the display unit and a semiconductor element that constitutes a display unit driving circuit may be formed on the substrate of the display device. In such a case, when the semiconductor elements that constitute the communication integrated circuit have the same structure as that of the other semiconductor elements, it is possible to simultaneously form the above-mentioned semiconductor elements.

[0018]

It is preferable that at least a part of the antenna be formed on the substrate in a region excluding the display unit, be formed for example along one peripheral edge of the substrate.

According to this structure, it is possible to arrange the antenna using the peripheral edge (the frame region) of the substrate that originally has a space without deteriorating the display.

[0019]

When the conductor is formed above the antenna on the substrate to constitute the corresponding display device, it is preferable that the conductor do not overlap the antenna in plan view. In short, the conductor preferably does not exist above the antenna.

Even if the conductor exists above the antenna, since radio waves circulate and reach the antenna, communications can be performed. However, when the conductor exists above the antenna, part of the radio waves may be shielded. Therefore, in order to correctly perform the communications, it is preferable that the conductor does not exist above the antenna.

[0020]

A display device according to the present invention comprises at least one substrate provided with a display unit and display-unit-driving wiring lines, and a radio communication device having a communication integrated-circuit unit and an antenna, and is characterized in that at least a part of the radio communication device is directly formed on the substrate.

According to this structure, it is possible to realize a display device that does not require a special space for providing the radio communication device and that is capable of reducing the amount of time and effort required for

providing the radio communication device.

[0021]

An electronic apparatus according to the present invention comprises the above display device according to present invention.

According to this structure, it is possible to easily manage products and processes and to realize an electronic apparatus including a display device that can be used as an information writing/reading device.

[0022]

[Description of the Embodiments]

[First Embodiment]

A first embodiment of the present invention will be described with reference to Figs. 1 to 7.

A display device according to the present embodiment is an example of a transmissive liquid crystal display device in an active matrix using an amorphous silicon thin film transistor (Thin Film Transistor) as a pixel switching element.

Fig. 1 is a plan view of a liquid crystal display device according to the present embodiment. Figs. 2 and 3 illustrate the section of the liquid crystal display device. Fig. 2 is a sectional view taken along the line A-A' of Fig. 1. Fig. 3 is a sectional view taken along the line B-B' of Fig. 1. Figs. 4 to 6 are plan views illustrating

modifications of the arrangement of an antenna. Fig. 7 is a sectional view of part of the structure of Fig. 6. In the respective drawings, in order to make the respective components visualized, the reduced scales of the respective components vary.

[0023]

The liquid crystal display device according to the present embodiment includes a liquid crystal cell 1 and two FPCs 2 and 3 (external substrates) connected to the liquid crystal cell 1 as illustrated in Figs. 1. The liquid crystal cell 1 includes a rectangular element substrate 4 and a counter substrate 5. A liquid crystal layer 50 is interposed between the element substrate 4 and the counter substrate 5. The width and the length of the element substrate 4 are larger than the width and the length of the counter substrate 5. In Fig. 1, in the element substrate 4 and the counter substrate 5, the right sides overlap each other and the bottom sides overlap each other so that the left side and the top side of the element substrate 4 protrude from the counter substrate 5. A sealing material 6 is provided along the edge of the counter substrate 5 and a rectangular frame of light-shielding film 7 is provided inside the sealing material. A region bounded by the light-shielding film 7 is a display unit 8 that actually contributes to the display. A plurality of data lines 9

(display-unit-driving wiring lines) and a plurality of scanning lines 10 (display-unit-driving wiring lines) are arranged in a matrix in the display unit 8. A plurality of pixels 11 constituted of regions surrounded by the data lines 9 and the scanning lines 10 is arranged in a matrix. An amorphous silicon TFT and a pixel electrode (not shown in Fig. 1) are provided in each of the pixels 11.

[0024]

The plurality of data lines 9 and the plurality of scanning lines 10 extend to the outside of the display unit 8. External connection terminals (not shown) are provided at the ends of the data lines 9 and the scanning lines 10 in non-display portion at the left end and the top end of the element substrate 4. The FPCs 2 and 3 that are elastically deformable films are attached to the left end and the top end of the element substrate 4, respectively. Wiring line patterns (not shown) on the FPCs 2 and 3 and external connection terminals on the element substrate 4 are electrically connected to each other. A data line driving data driver IC 12 and a scanning line driving gate driver IC 13 are mounted on the FPCs 2 and 3, respectively. The respective pixels 11 in the display unit 8 are driven by signals from the driver ICs 12 and 13. A radio communication device 14 is provided along the right side of the liquid crystal cell 1 in Fig. 1. The radio

communication device 14 includes a memory, an IC chip 15 (a communication integrated circuit) in which a CPU is mounted, and an antenna 16 for transmitting and receiving radio waves. According to the present embodiment, the IC chip 15 is mounted on the top right corner of the element substrate 4. The antenna 16 is formed along the right side of the element substrate 4 to which the FPCs 2 and 3 are not attached.

[0025]

In the sectional structure of the liquid crystal display device, as illustrated in Fig. 2, a pixel switching TFT 19 is formed on the internal surface (the surface facing a liquid crystal layer 50) of a glass substrate 18 that constitutes the element substrate 4. A pixel switching TFT 19 includes a gate electrode 20 (a scanning line 10), a gate insulating film 21, a semiconductor layer 22, a source layer 23, a drain layer 24, a source electrode 25 (a data line 9), and a drain electrode 26 and is covered with an interlayer insulating film 27. A contact hole 28 is formed in the interlayer insulating film 27. A pixel electrode 29 made of a transparent conductive film such as ITO (Indium Tin Oxide) is connected to the drain electrode 26 through the contact hole 28. An alignment film 30 is formed on the outermost surface of the element substrate 4. A light-shielding film 7 made of a metal having a low light reflection ratio such

as Chrome is formed on the internal surface (the surface facing the liquid crystal layer 50) of a glass substrate 32 that constitutes the counter substrate 5. An insulating film 33 that covers the light-shielding film 7 is further formed. A common electrode 34 is formed on the insulating film 33. An alignment film 35 is formed on the outermost surface of the counter substrate 5. The antenna 16 is formed in a region below the sealing material 6 on the glass substrate 18 that constitutes the element substrate 4. The antenna 16 is formed outside the light-shielding film 7, that is, outside the display unit 8. The antenna 16 is formed on the same layer as the gate electrode 20 (the scanning line 10) of the pixel switching TFT 19. That is, the antenna 16 and the gate electrode 20 (the scanning line 10) are made of the same material such as aluminum used as a typical wiring line material by the same manufacturing process. In the entire structure of the liquid crystal cell 1, conductive films such as the common electrode 34 and the light-shielding film 7 are formed above the antenna 16 (on a layer facing the counter substrate 5). However, the conductive films are arranged so as not to overlap the antenna 16 in plan view.

[0026]

The sectional structure of a connection between the IC chip 15 and the antenna 16 is illustrated in Fig. 3.

That is, the IC chip 15 has a plurality of bumps 52 for connection and is mounted on the element substrate 4 through the bumps 52, which is referred to as COG (Chip On Glass) mounting. A contact hole 53 that reaches the top face of the antenna 16 is formed in the interlayer insulating film 27 and the gate insulating film 21. A relay conductor 54 is formed so as to cover the internal surface of the contact hole 53 and to extend onto the interlayer insulating film 27. As a result, the relay conductor 54 and the antenna 16 are electrically connected to each other in the contact hole 53. The bumps 52 of the IC chip 15 are electrically connected to the end of the relay conductor 54 through an anisotropic conductive film 55. The relay conductor 54 is formed on the same layer as the pixel electrode 29. That is, the relay conductor 54 and the pixel electrode 29 are made of the same material such as ITO by the same manufacturing process. As mentioned above, according to the present embodiment, the antenna 16 is formed on the same layer (of the same material) as the gate electrode 21 by the same process. Also, the relay conductor 54 is formed on the same layer (of the same material) as the pixel electrode 29 by the same process. Though not shown, when a power source voltage or a signal is input to the IC chip 15, which may be input through wiring lines on the FPCs 2 and 3 and wiring lines constituted of the same layers as the scanning lines

10 and the data lines 9 on the element substrate 4.

[0027]

In the liquid crystal display device according to the present embodiment, the entire antenna 16 that constitutes the radio communication device 14 is formed on the same layer and of the same material as the gate electrode 20 (the scanning line 10) outside the display unit 8 of the liquid crystal cell 1 by the same process. According to this structure, it is not necessary to provide a space for attaching the antenna 16 unlike in the case where the IC tag on the market is attached to the liquid crystal display device. Therefore, it is possible to reduce the amount of time and effort required for attaching the antenna 16. When as the radio communication device 14, the IC chip 15 as represented by the reference numeral T of Fig. 14 includes a memory 57 (a writing unit) for storing information, information concerning the corresponding display device such as the product identification information and the product record information is stored so as to use a wireless IC tag for the managements of products and processes during production and distribution processes. In the prior art, processes are managed with respect to several hundreds or thousands of liquid crystal display devices in units of lots. However, according to the present invention, processes can be managed with respect to each liquid crystal

display device. Therefore, the flexibility of processes increases. When the IC chip 15 as represented by the reference numeral R of Fig. 14 includes a controller 58 of a transmitting and receiving unit, the controller 58 can be used as a reader/writer for writing information in and reading information from another radio communication device.

[0028]

According to the present embodiment, since the IC chip 15 is mounted on the element substrate 4 of the liquid crystal cell 1, it is possible to easily mount the radio communication device 14 on the element substrate 4 by mounting a previously prepared IC chip 15. In particular, when the IC chip 15 is mounted right after the liquid crystal cell 1 is completed, it is possible to begin to manage products and processes using the radio communication device 14 from a point before connecting a driving FPC to the radio communication device 14. According to the present embodiment, since the antenna 16 and the relay conductor 54 for connecting the IC chip 15 to the antenna 16 are formed on the same layer (of the same material) as the pixel electrode 29 by the same process, it is possible to limit the number of processes so as to form the relay conductor 54 and to prevent the manufacturing processes from being complicated. Further, since a conductor such as the common electrode 34 and the light-shielding film 7, which

constitutes the liquid crystal display device, is arranged so as not to overlap the antenna 14 in plan view, it is possible to prevent radio waves from being shielded by the conductor and to correctly write and read information.

[0029]

According to the present embodiment, the antenna 16 is formed on the same layer as the gate electrode 20. However, it may be formed on the same layer as the data line 9 or the pixel electrode 29. The antenna may be formed on a plurality of layers. Also, the layer that constitutes the relay conductor 54 for connecting the IC chip to the antenna is not limited to the same layer as the pixel electrode 29. A structure of mounting the IC chip 15 on the substrate is not limited to the COG method. The IC chip may be directly connected to the antenna without passing through the relay conductor 54. The driving driver ICs 12 and 13 may be directly mounted on the element substrate 4 by the COG method as well as being mounted on the FPCs 2 and 3. It is possible to appropriately change the connection arrangement based on the type of the pixel switching TFT 19 and the type (transmissive/reflective/transflective) of the liquid crystal display device.

[0030]

As illustrated in Fig. 4 as well as Fig. 1, the antenna 16 may turn at the corner K of the element substrate 4 at an

angle of 90° and thus may be arranged along two sides. As illustrated in Fig. 5, the antenna 16 may be multi-arranged so as to extend along one side and to turn at the corner K of the element substrate 4 at an angle of 180° to thus be returned. As illustrated in Fig. 6, the antenna 16 may be arranged along three or more sides. In the case of Fig. 6, according to the present embodiment, when the antenna 16 is formed on the same layer as the scanning line 10, the antenna 16 is short circuited against the scanning lines 10 that extend toward the gate driver IC 13 on the FPC 2 outside the display unit 8, which may cause some problems. Therefore, in the portions (the portions G in Fig. 6) through which the scanning lines 10 pass, as illustrated in Fig. 7, it is necessary to form an antenna 16d on the same layer as the data line 9 through a relay conductor 56 formed on the same layer as the pixel electrode 29 and not to short circuit the antenna 16d against the scanning lines 10 that are provided under the antenna 16d. When it is necessary to increase the length of the antenna 16, the antenna 16 may wind around the display unit 8 several times.

[0031]

[Second Embodiment]

A second embodiment of the present invention will now be described with reference to Figs. 8 and 9.

The basic structure of the liquid crystal display

device according to the present embodiment is the same as the structure of the first embodiment excluding the position in which the IC chip is mounted and the structure of the antenna in accordance with the position of the IC chip.

Fig. 8 is a plan view of the liquid crystal display device according to the present embodiment. Fig. 9 is a sectional view taken along the line C-C' of Fig. 8, which illustrates the sectional structure of the liquid crystal display device. In Figs. 8 and 9, the same components as those of Figs. 1 to 3 are denoted by the same reference numerals and the detailed description thereof will be omitted.

[0032]

According to the first embodiment, the IC chip 15 is mounted on the element substrate 4 of the liquid crystal cell 1. The entire antenna 16 is formed on the element substrate 4. On the other hand, according to the present embodiment, as illustrated in Fig. 8, the IC chip 15 is mounted on the FPC 2 (an external substrate). The antenna 16 is constituted of the first antenna 16a formed on the element substrate 4 and the second antenna 16b provided on the FPC 2.

[0033]

According to the sectional structure illustrated in Fig. 9, the first antenna 16a on the element substrate 4 is

formed on the same layer as the scanning line 10 like in the first embodiment. The contact hole 53 that reaches the top face of the first antenna 16a is formed in the interlayer insulating film 27 and the gate insulating film 21. The relay conductor 54 formed on the same layer as the pixel electrode 29 covers the internal surface of the contact hole 53 and extends onto the interlayer insulating film 27. Therefore, the relay conductor 54 and the first antenna 16a are electrically connected in the contact hole 53. On the other hand, the second antenna 16b made of a copper wiring line like another typical FPC wiring line is provided on the FPC 2. The relay conductor 54 on the first antenna 16a and the second antenna 16b are electrically connected to each other through an anisotropic conductive film 65. The bumps 52 of the IC chip 15 are electrically connected to the end of the second antenna 16b through an anisotropic conductive film 55. The copper wiring line on the FPC 2 may be appropriately connected to the IC chip 15 and a power source voltage or a signal may be input through the wiring line.

[0034]

In the liquid crystal display device according to the present embodiment, it is not necessary to provide a special space for attaching the antenna unlike the case where the IC tag on the market is attached to the liquid crystal display device. Therefore, it is possible to reduce the amount of

time and effort required for attaching the antenna to the liquid crystal display device. Since the antenna 16a and the relay conductor 54 are formed on the same layer (of the same material) as the other conductors by the same process, it is possible to limit the number of processes and thus to prevent the manufacturing processes from being complicated like in the first embodiment.

[0035]

According to the present embodiment, even if the liquid crystal cell 1 is small and the first antenna 16a formed on the element substrate 4 is not long enough, it is possible to compensate the inadequate of the length of the entire antenna 16 with the second antenna 16b on the FPC 2 and to thus obtain an entire antenna having a desired performance. Therefore, it is possible to improve the degree of freedom in designing the antenna. Since many wiring lines are originally provided on the FPC 2, it is not necessary to provide the additional wiring line that serves as the second antenna 16b on the FPC 2.

[0036]

The FPC may be connected to the element substrate of the liquid crystal cell and to a printed wiring line board on which various electronic parts are mounted. According to this structure, the IC chip may be mounted on the printed wiring line board not on the FPC. In this case, in addition

to the first antenna on the element substrate and the second antenna on the FPC, a wiring line (a conductor) on the print wiring line plate may be used as a third antenna to thus constitute the entire antenna.

[0037]

[Third Embodiment]

A third embodiment of the present embodiment will be described with reference to Fig. 10.

A display device according to the first and second embodiments is a liquid crystal display device using an amorphous silicon TFT as a pixel switching element. On the other hand, a display device according to the present embodiment is a liquid crystal display device using polycrystalline silicon TFT or a single crystal silicon TFT as a pixel switching element.

Fig. 10 is a plan view of a liquid crystal display device according to the present embodiment.

[0038]

The amorphous silicon TFT cannot constitute a communication integrated circuit in an IC chip that constitutes a radio communication device in consideration of driving ability as a transistor. On the other hand, the polycrystalline silicon TFTs or the single crystal silicon TFTs have enough driving ability to constitute the communication integrated circuit. Therefore, according to

the present embodiment, as illustrated in Fig. 10, a communication integrated circuit 71 (a communication integrated-circuit unit) is directly formed on the element substrate 4 using a plurality of polycrystalline silicon TFTs or a plurality of single crystal silicon TFTs. When the polycrystalline silicon TFTs or the single crystal silicon TFTs are used, it is possible to form a data line driving circuit 72 and a scanning line driving circuit 73 that include N channel TFTs or P channel TFTs if necessary on the element substrate 4. Therefore, it is possible to simultaneously form the TFTs that constitute the communication integrated circuit 71 and the TFTs that constitute the data line driving circuit 72 and the scanning line driving circuits 73 by the same process. Any conductor that constitutes the element substrate 4 may be used as the antenna 16. For example, the antenna 16 may be simultaneously formed of aluminum of which the data lines 9 are made by the same process as the data lines 9. A conductor that constitutes scanning lines 10, capacitor electrodes, a light-shielding layer, a shield layer, and pixel electrodes may be used as for the antenna 16.

[0039]

In the liquid crystal display device according to the present embodiment, it is not necessary to provide a special space for attaching the antenna like in the case where the

IC tag on the market is attached to the liquid crystal display device. Also, it is possible to reduce the amount of time and effort required for attaching the antenna to the liquid crystal display device. Since the antenna 16 is formed on the same layer (of the same material) as the other conductors by the same process, it is possible to limit the number of processes and to prevent the manufacturing processes from being complicated like in the above embodiments. So thus, it is possible to obtain the same effect as the above embodiments. According to the present embodiment, since a radio communication device 14 is formed on the substrate in a state of the element substrate 4 prior to a step where the element substrate 4 is completed as a liquid crystal cell is completed, it is possible to previously write information at the substrate state of fabrication. As a result, the traceability of products is excellent.

[0040]

[Fourth Embodiment]

A fourth embodiment of the present invention will be described with reference to Figs. 11 and 12.

A display device according to the first to third embodiments is a liquid crystal display device using a TFT as a pixel switching element. On the other hand, a display device according to the present embodiment is a liquid

crystal display device using a TFD (thin film diode) as a pixel switching element.

Fig. 11 is a plan view of the liquid crystal display device according to the present embodiment. Fig. 12 is a sectional view taken along the line D-D' of Fig. 11, which illustrates the sectional structure of the liquid crystal display device.

[0041]

The schematic structure of the liquid crystal display device according to the present embodiment is almost the same as that of the first embodiment. As illustrated in Fig. 11, the liquid crystal display device according to the present embodiment includes the liquid crystal cell 1 and the two FPCs 2 and 3. The liquid crystal cell 1 includes the element substrate 4 and the counter substrate 5 that face each other. The FPCs 2 and 3 are attached to the element substrate 4 and the counter substrate 5, respectively. The data driver IC 12 and the gate driver IC 13 are mounted on the FPCs 2 and 3, respectively. The radio communication device 14 is provided along the top side of the liquid crystal cell 1 in Fig. 11. According to the present embodiment, the IC chip 15 is mounted on the top left corner of the element substrate 4. The antenna 16 is formed along the top side of the element substrate 4.

[0042]

According to the sectional structure of the liquid crystal display device, as illustrated in Fig. 12, a base insulating film 81 made of TaOx (Tantalum Oxide) is formed on the internal surface (the surface facing a liquid crystal layer 50) of a glass substrate 18 that constitutes the element substrate 4. A pixel switching TFD 82 is formed on the base insulating film 81. A pixel electrode 83 made of a transparent conductive film is connected to the pixel switching TFD 82. An alignment film 30 is formed on the outermost surface thereof. A counter electrode 84 and a light-shielding film 7 are formed on the internal surface (the surface facing the liquid crystal layer 50) of a glass substrate 32 that constitutes the counter substrate 5. An alignment film 35 is formed on the outermost surface. The antenna 16 is formed on the base insulating film 81 of the element substrate 4. The antenna 16 is formed outside the light-shielding film 7 of the counter substrate 5, that is, outside the display unit 8. The antenna 16 is formed on the same layer as a Ta electrode 85 of the pixel switching TFD 82. That is, the antenna 16 and the Ta electrode 85 are made of the same material by the same manufacturing process. The conductive films such as the counter electrode 84 and the light-shielding film 7 above the antenna 16 (on a layer facing the counter substrate 5) are arranged so as not to overlap the antenna 16 in plan view.

[0043]

In the liquid crystal display device according to the present embodiment, it is not necessary to provide a special space for attaching the antenna unlike in the case where the IC tag on the market is attached to the liquid crystal display device. Also, it is possible to reduce the amount of time and effort required for attaching the antenna. Since the antenna is formed on the same layer (of the same material) as the other conductors by the same process, it is possible to limit the number of processes and to prevent the manufacturing processes from being complicated like in the above embodiments.

[0044]

[Electronic Apparatus]

An embodiment of the electronic apparatus according to the present invention will now be described with reference to Fig. 13.

Fig. 13 illustrates a wrist type reader/writer (an electronic apparatus) 101 as an example of the electronic apparatus using the liquid crystal display device according to the above embodiments. The wrist type reader/writer 101 can be attached to the wrist or a palm of a user like a watch. For example, if a wireless IC tags are attached to products in a department store or a market when a user brings his or her hand close to a product in order to read

the information written in the wireless IC tag attached to the product, a radio communication device 103 in the reader/writer 101 reads the information from the wireless IC tag. The information read from the wireless IC tag is displayed in a liquid crystal display 105. In addition, it is possible to rewrite the information in the wireless IC tag attached to the product.

[0045]

Since the reader/writer 101 according to the present embodiment can be worn round a user's wrist, the user can freely move his or her hands and fingers. Therefore, the user can freely lift products and thus can conveniently use the reader/writer 101. Also, it is possible to prevent his or her privacy from being invaded by using the writhing function. For example, when the wireless IC tag is thrown away, the others may obtain information concerning the products that the user bought and the taste of the user from the thrown away wireless IC tag. In this case, the user preferably deletes or changes the information using the function of the writer before the user throws away the wireless IC tag. Further, the function as a watch may be added to the reader/writer 101 according to the present embodiment so that time is displayed on a liquid crystal display 103, in this case when the function of the reader/writer is not used, the reader/writer 101 can be used

as a wristwatch. According to other embodiments, the present invention can be applied to personal computers, PDAs, portable TVs, mobile telephones, digital cameras, vehicles, measuring apparatuses, and television sets.

[0046]

The scope of the present invention is not limited to the above embodiments and various changes in form and details may be made therein without departing from the spirit and scope of the present invention. For example, the active matrix liquid crystal display device is described in the above embodiments. However, it is possible to form the radio communication device in a passive matrix liquid crystal display device. Further, it is possible to apply the present invention to display devices such as a plasma display panel (PDP), a field emission display (FED), and a fluorescent display tube as well as the liquid crystal display device. In the PDP, an antenna is preferably formed together with an address electrode, a bus electrode, and a display electrode by the same process. In the FED, an antenna is preferably formed together with a gate electrode and a cathode by the same process. In the fluorescent display tube, an antenna is preferably formed together with an anode by the same process.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a plan view of a liquid crystal

display device according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a sectional view taken along the line A-A' of Fig. 1.

[Fig. 3] Fig. 3 is a sectional view taken along the line B-B' of Fig. 1.

[Fig. 4] Fig. 4 is a plan view illustrating a modification of the arrangement of an antenna.

[Fig. 5] Fig. 5 is a plan view illustrating another modification of the arrangement of the antenna.

[Fig. 6] Fig. 6 is a plan view illustrating still another modification of the arrangement of the antenna.

[Fig. 7] Fig. 7 is a sectional view of part of the structure of Fig. 6.

[Fig. 8] Fig. 8 is a plan view of a liquid crystal display device according to a second embodiment of the present embodiment.

[Fig. 9] Fig. 9 is a sectional view taken along the line C-C' of Fig. 8.

[Fig. 10] Fig. 10 is a plan view of a liquid crystal display device according to a third embodiment of the present embodiment.

[Fig. 11] Fig. 11 is a plan view of a liquid crystal display device according to a fourth embodiment of the present invention.

[Fig. 12] Fig. 12 is a sectional view taken along the line D-D' of Fig. 11.

[Fig. 13] Fig. 13 is a perspective view illustrating an example of an electronic apparatus according to the present invention.

[Fig. 14] Fig. 14 is a view explaining the function of a radio communication device.

[Reference Numerals]

1: LIQUID CRYSTAL CELL

2, 3: FPC (EXTERNAL SUBSTRATE)

4: ELEMENT SUBSTRATE

5: COUNTER SUBSTRATE

7: LIGHT-SHIELDING FILM

8: DISPLAY UNIT

9: DATA LINE (DISPLAY UNIT DRIVING WIRING LINE)

10: SCANNING LINE (DISPLAY UNIT DRIVING WIRING LINE)

14: RADIO COMMUNICATION DEVICE

15: IC CHIP (COMMUNICATION INTEGRATED-CIRCUIT UNIT)

16, 16a, 16b, 16d: ANTENNA

54: RELAY CONDUCTOR

71: COMMUNICATION INTEGRATED CIRCUIT (COMMUNICATION INTEGRATED-CIRCUIT UNIT)

[Name of Document] ABSTRACT

[Abstract]

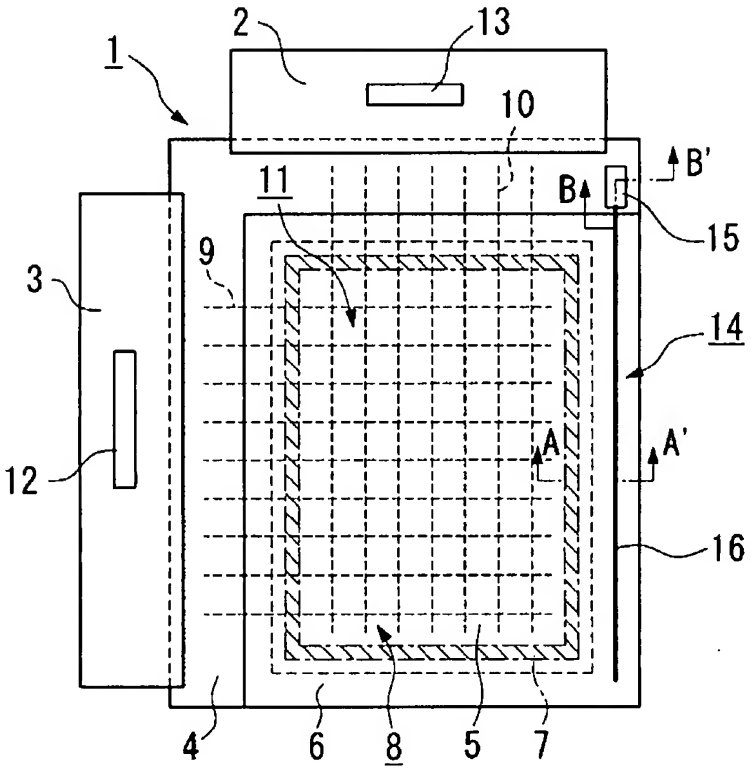
[Object] To provide a display device and an electronic apparatus including a radio communication device such as an IC tag, which do not need a special space for attaching the IC tag and is capable of reducing the amount of time and effort required for attaching the IC tag.

[Solving Means] A display device including a radio communication device 14 having at least one substrate provided with a display unit 8 and display-unit-driving wiring lines 9 and 10, a communication integrated-circuit unit 15, and an antenna 16 is provided. At least a part of the antenna 16 is formed on the substrate and formed of a conductor formed in the same layer as a conductor that constitute the display unit 8 or conductors that constitute the display-unit-driving wiring lines 9 and 10.

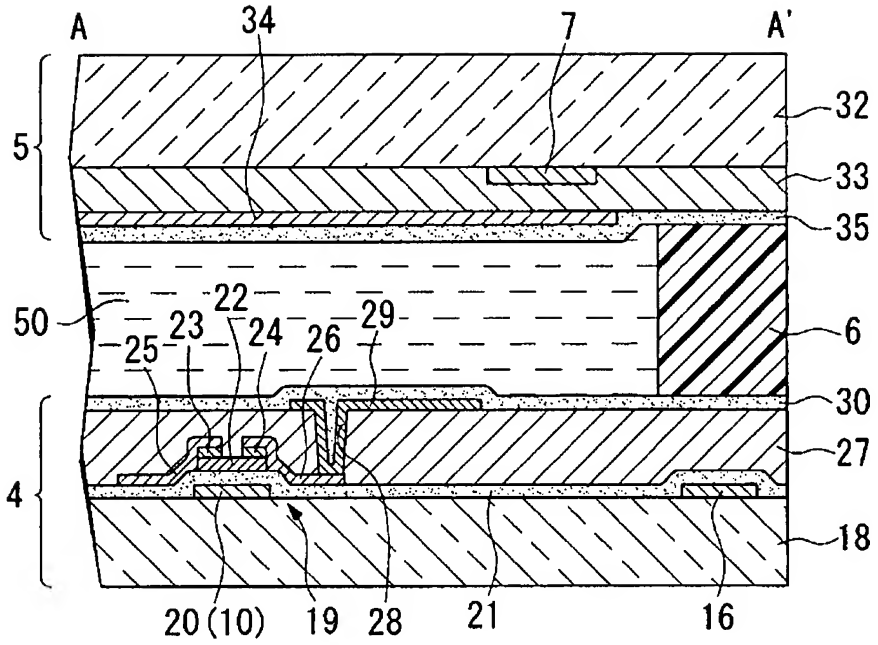
[Selected Figure] Fig. 1

[Name of Document] DRAWINGS

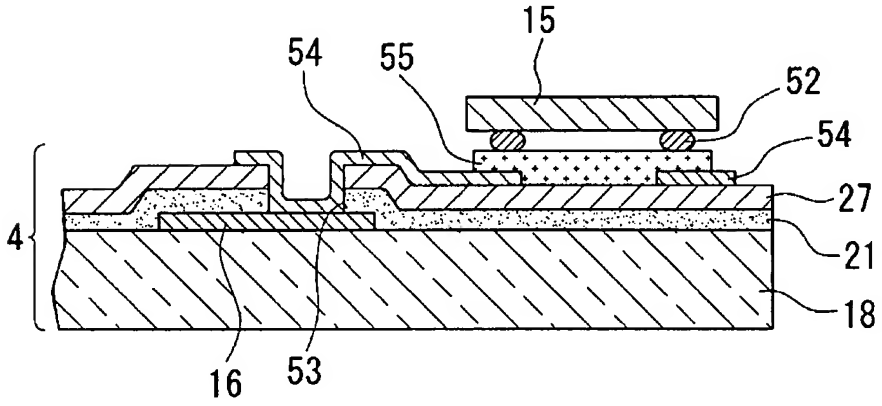
[FIG. 1]



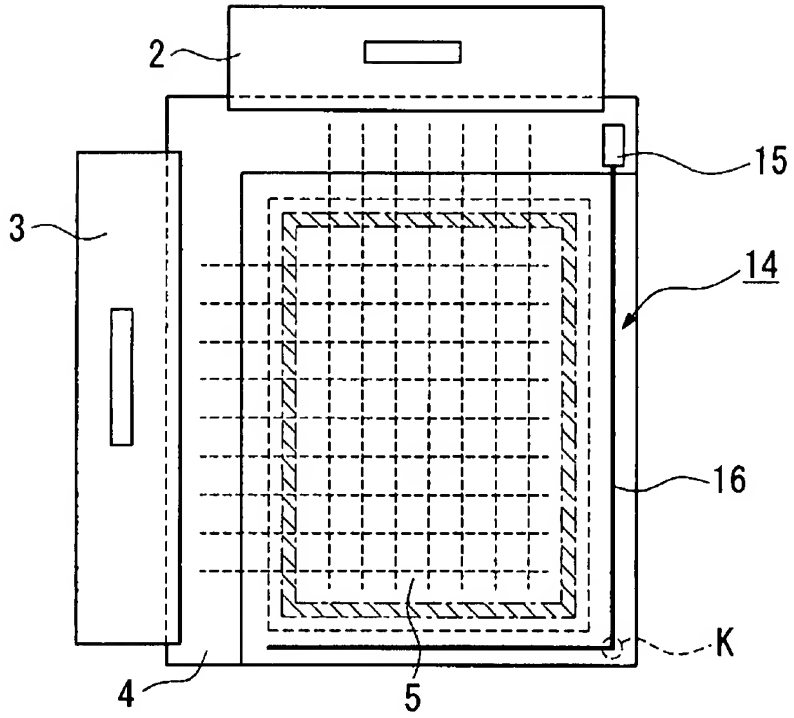
[FIG. 2]


A
34
7
A'
5
32
33
35
50
22
23
24
26
29
25
6
30
27
4
18
20 (10)
19
28
21
16

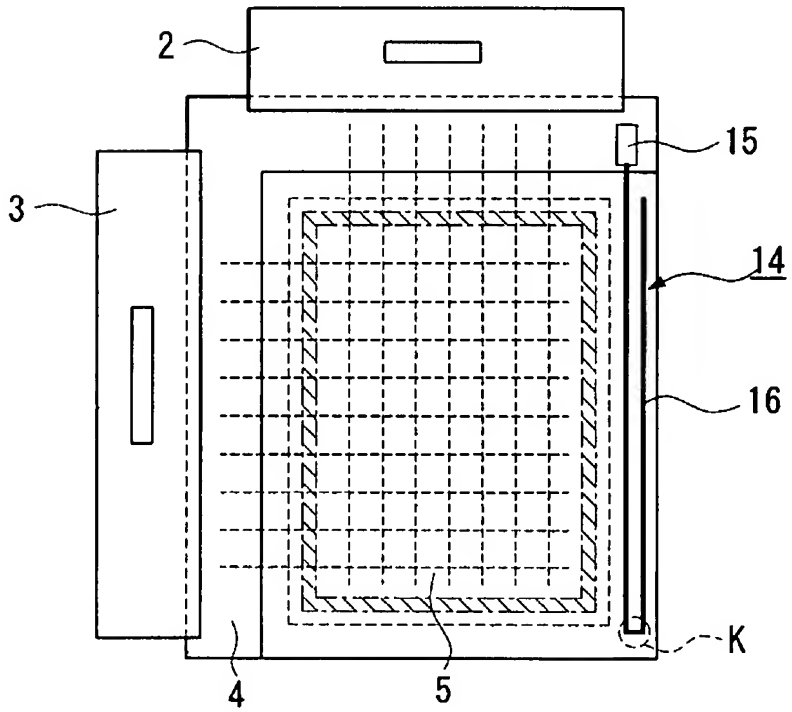
[FIG. 3]


15
54
55
52
54
27
4
21
18
16
53

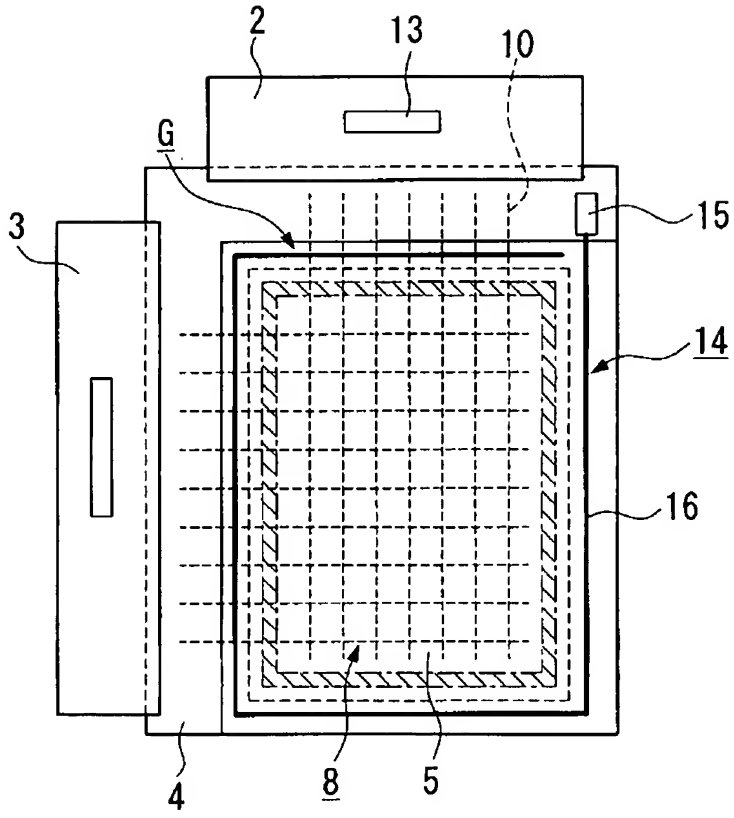
[FIG. 4]



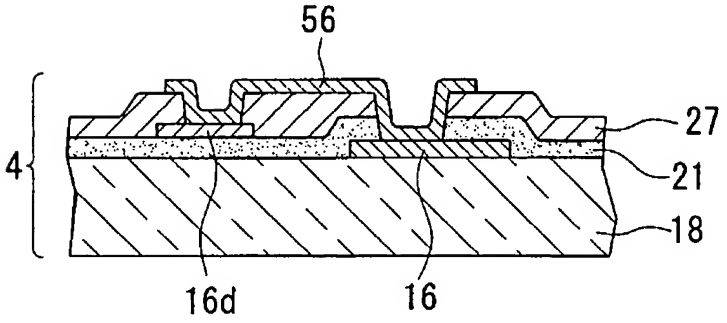
[FIG. 5]



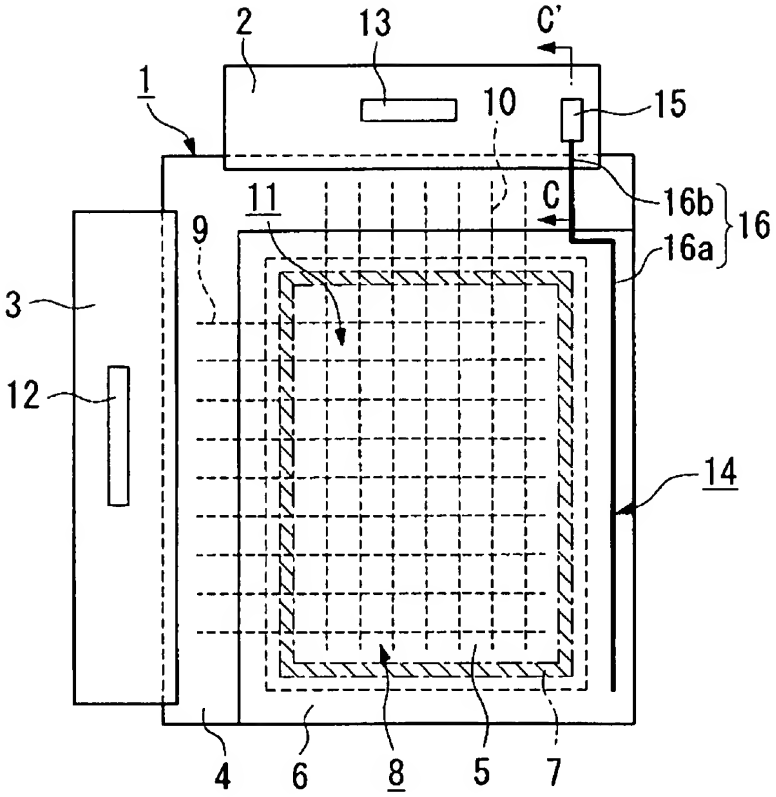
[FIG. 6]



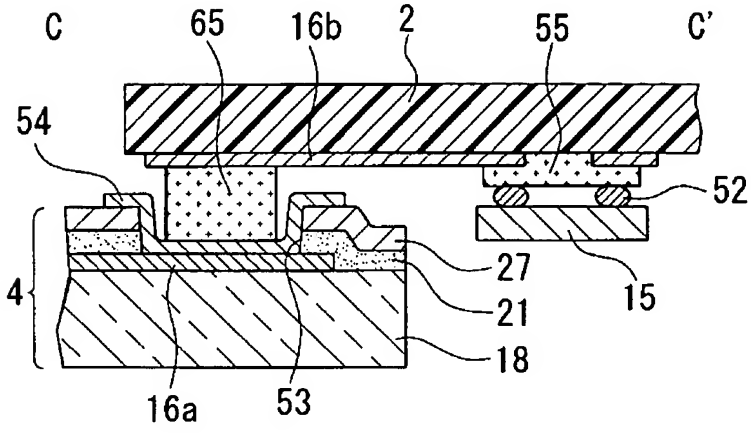
[FIG. 7]



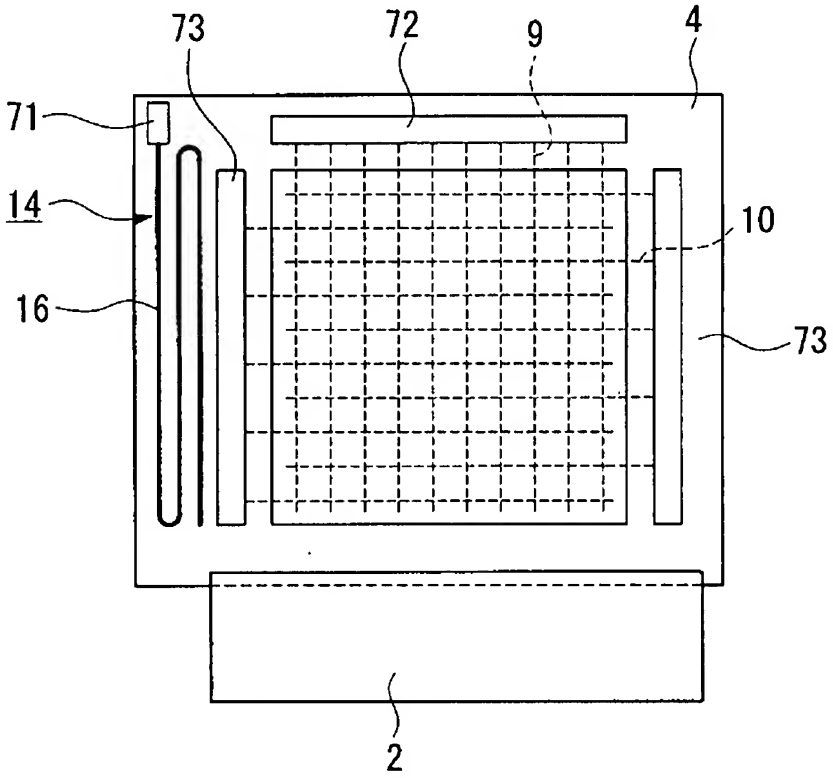
[FIG. 8]


2
13
C'
1
10
15
11
C
16b
16
9
16a
3
12
14
4
6
8
5
7

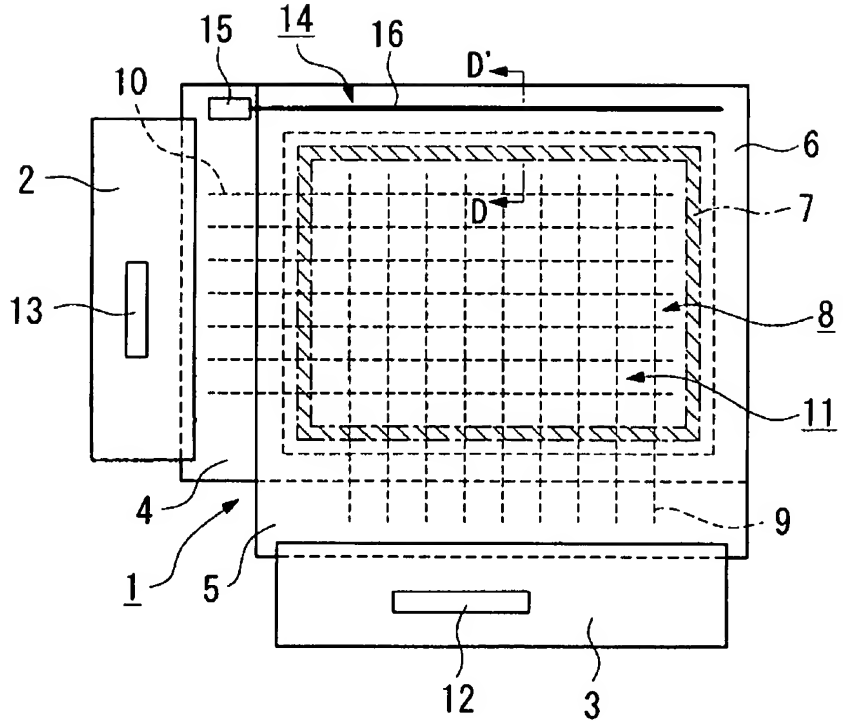
[FIG. 9]


C
65
16b
2
55
C'
54
52
27
4
21
15
18
16a
53

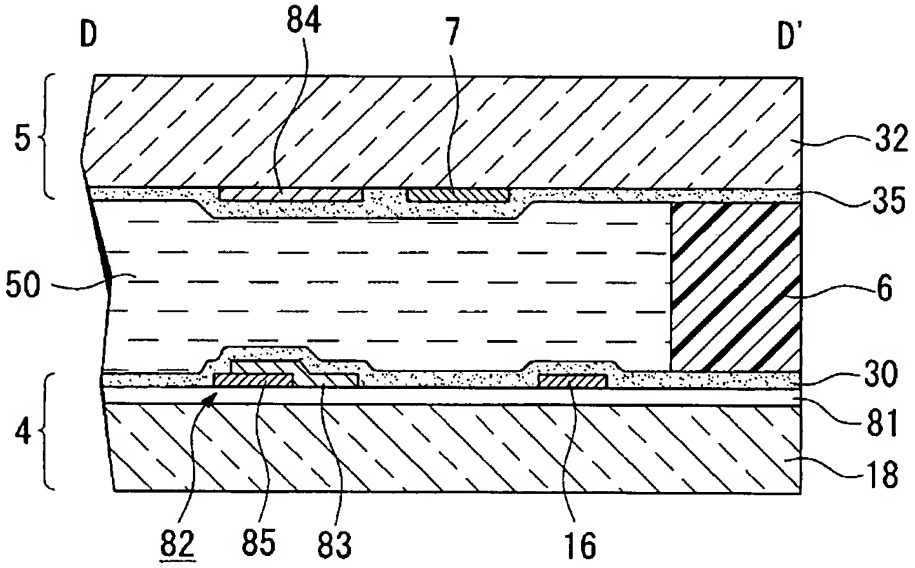
[FIG. 10]



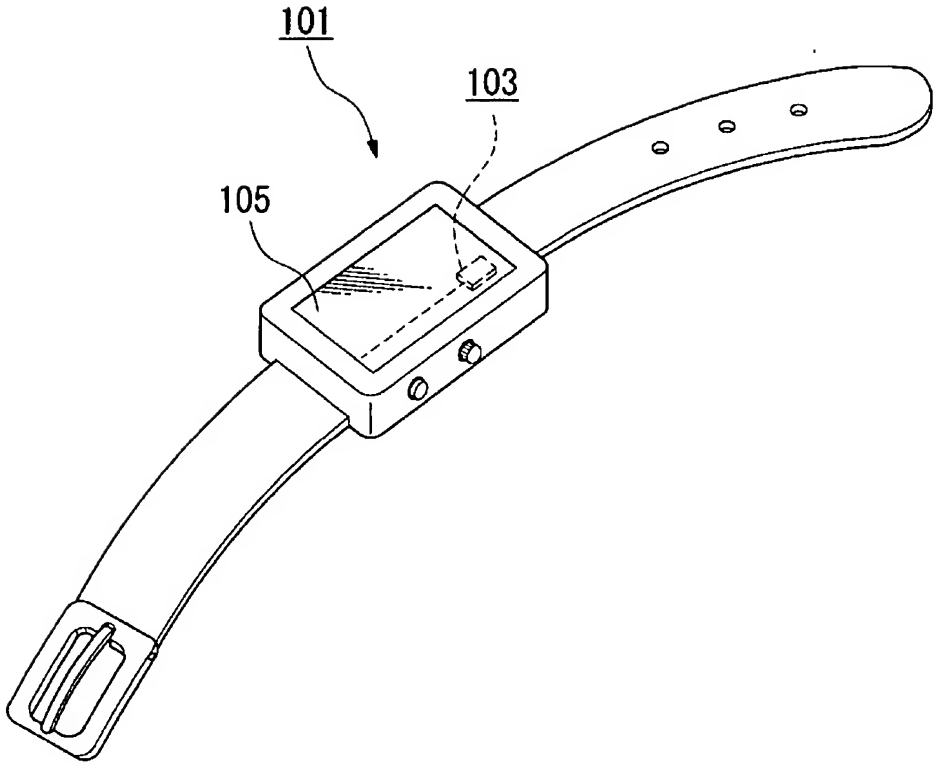
[FIG. 11]


15
14
16
D'
10
6
2
D
7
13
8
11
4
9
1
5
12
3

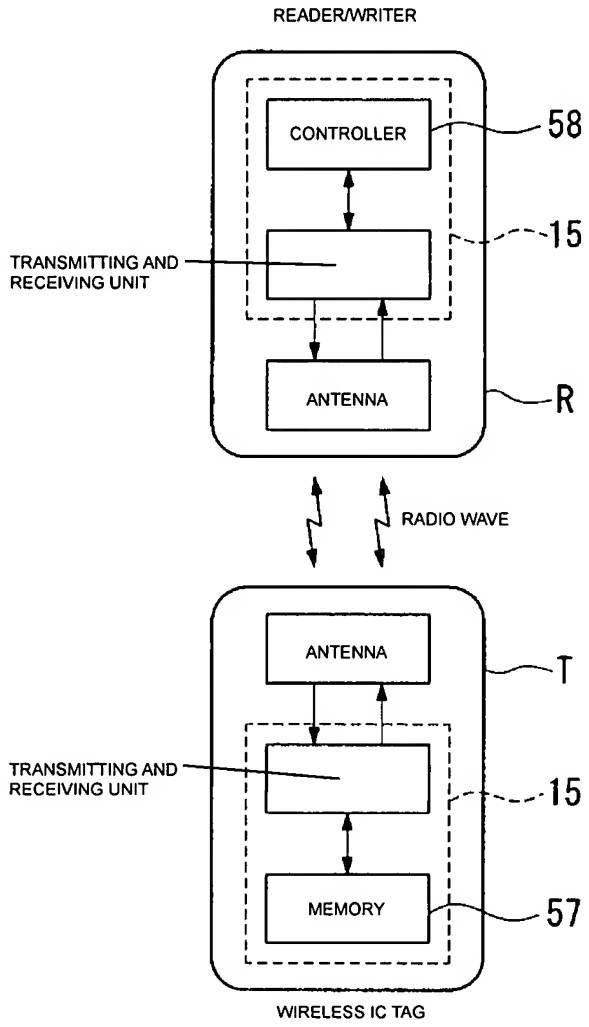
[FIG. 12]


D
84
7
D'
5
32
35
50
6
30
4
81
18
82
85
83
16

[FIG. 13]



[FIG. 14]


READER/WRITER
CONTROLLER
58
15
TRANSMITTING AND
RECEIVING UNIT
ANTENNA
R
RADIO WAVE
ANTENNA
T
TRANSMITTING AND
RECEIVING UNIT
15
MEMORY
57
WIRELESS IC TAG